Development of positive－tone molecular resist based on Phenyl[4]calixarene for EUVL

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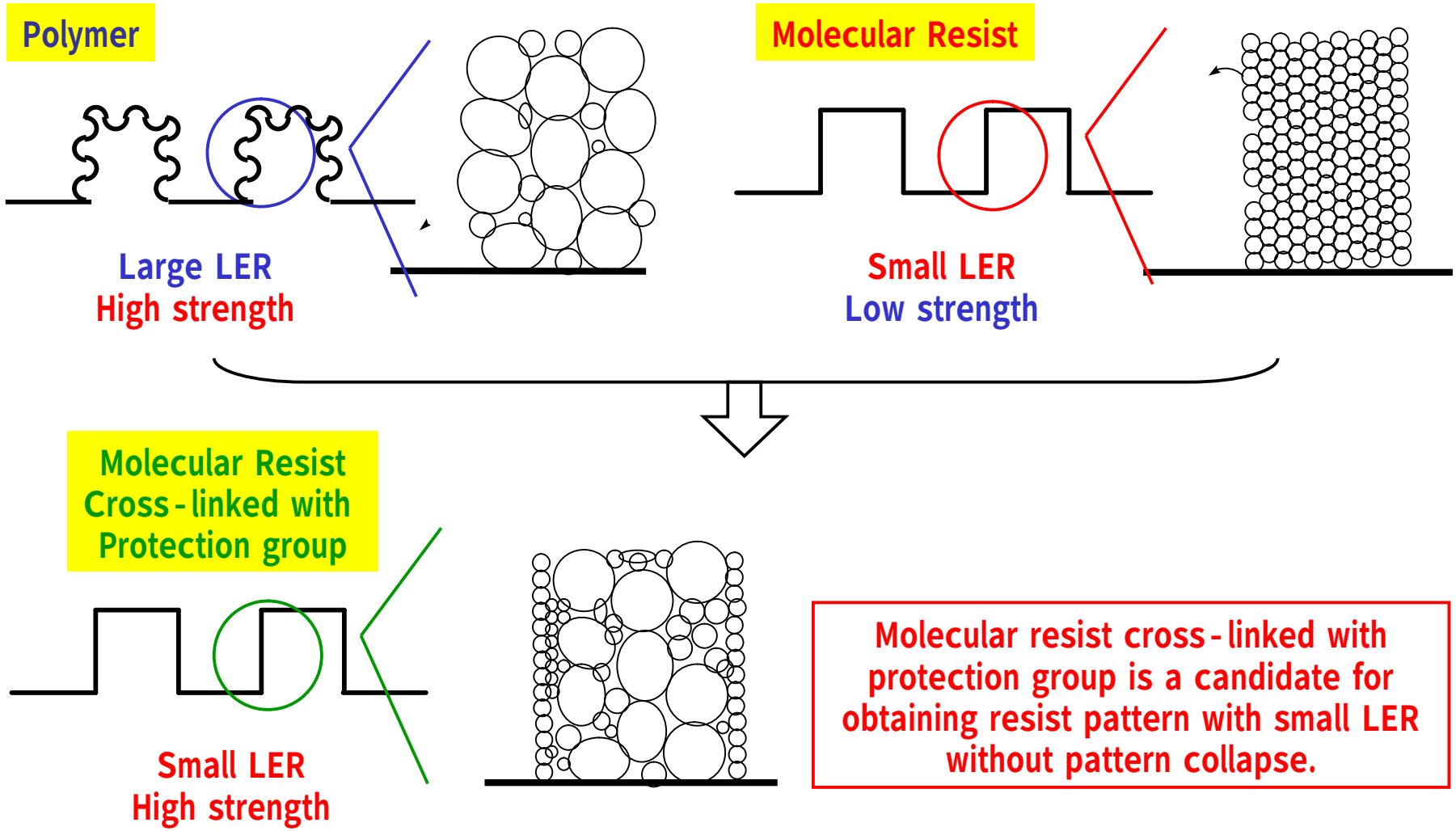
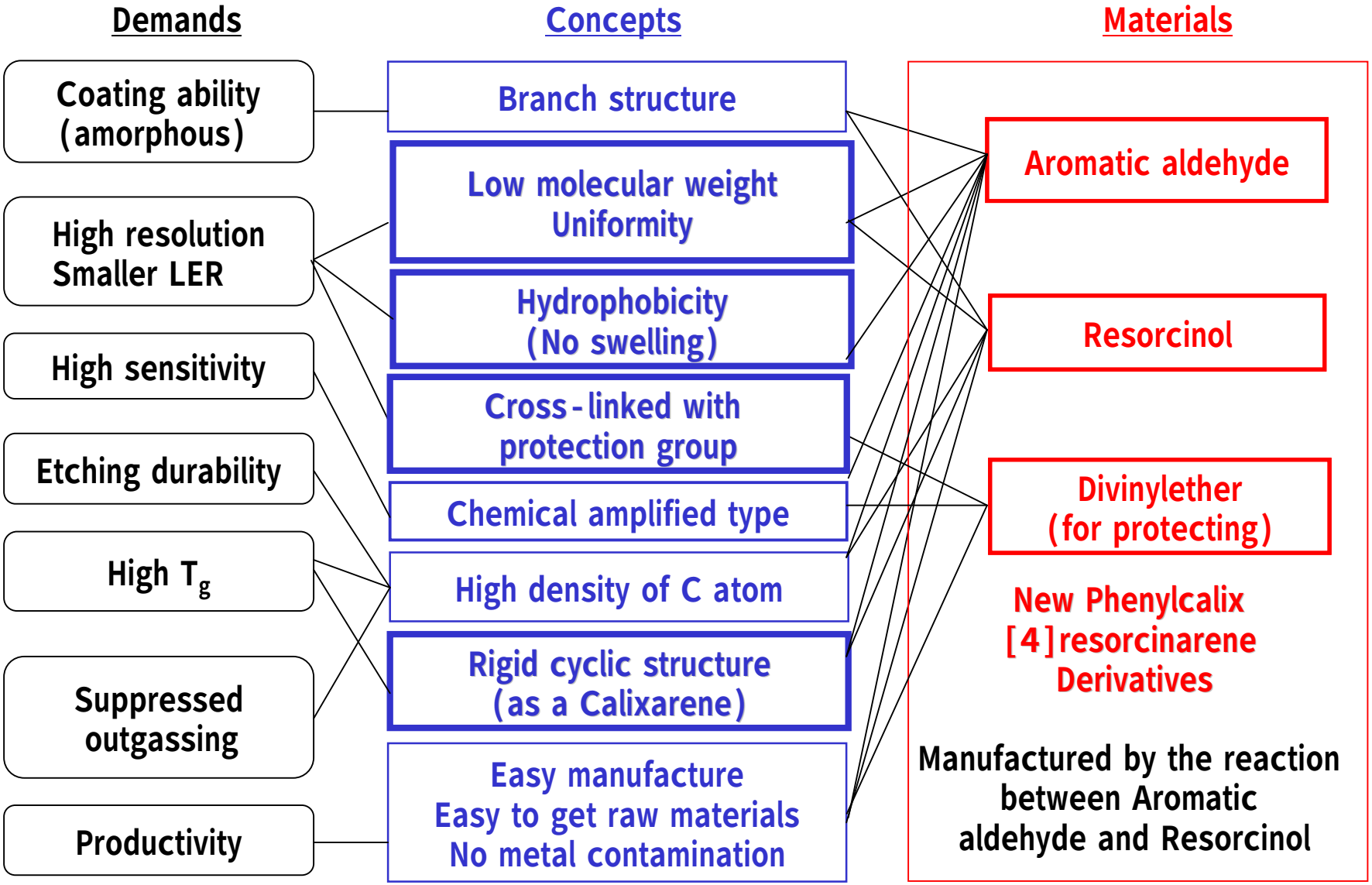
Approach from Positive－tone Resist Material for LER Reduction

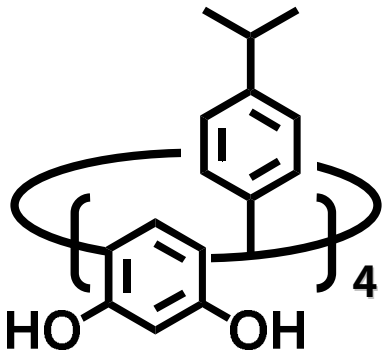


Molecular resist cross-linked with protection group is a candidate for obtaining resist pattern with small LER without pattern collapse.

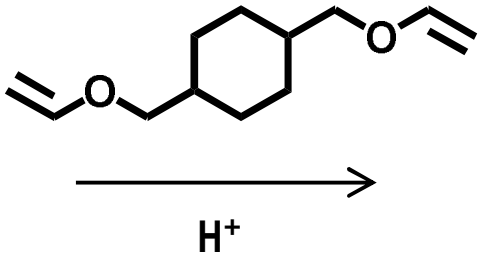
Design Concepts for New Positive－tone Molecular Resist Material Cross－linked with Protection Group

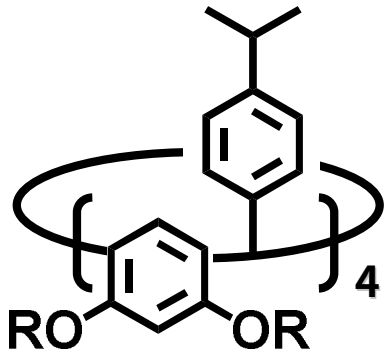


Synthesis Scheme of Molecular Resist Material Cross－linked with Protection Group

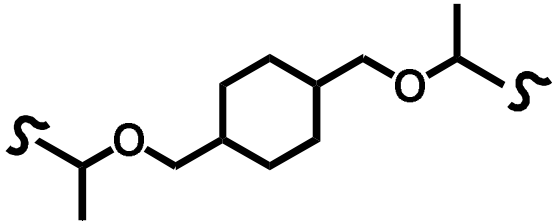


MGR104





R = H or



MGR104P－CHDVE

Molecular resist material cross-linked with protection group, MGR104P－CHDVE, was synthesized.

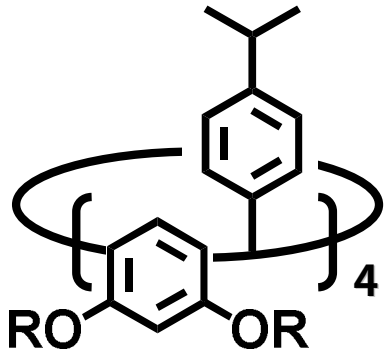
Solubility of Molecular Resist Material Cross－linked with Protection Group

	Reaction ratio of MGR104 / CHDVE (mol%)	Solubility for Resist Solvent [1)]	Solubility for Alkaline Developer [2)]
Run 1. MGR104P－CHDVE50	1 / 2 (50mol%)	Insoluble	-
Run 2. MGR104P－CHDVE25	1 / 4 (25mol%)	Soluble	Soluble
Ref. MGR104	No protect (0mol%)	Soluble	Insoluble

1) PGME (1－Methoxy－2－propanol)
2) Conventional Alkaline Developer (0.26N TMAH aq.)

MGR104 cross-linked with CHDVE (25mol%), MGR104P-CHDVE25, is suitable for positive-tone resist material.

Positive-tone Molecular Resist Material Cross-linked with Protection Group for EB/EUVL



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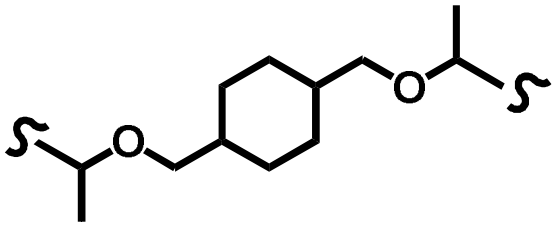
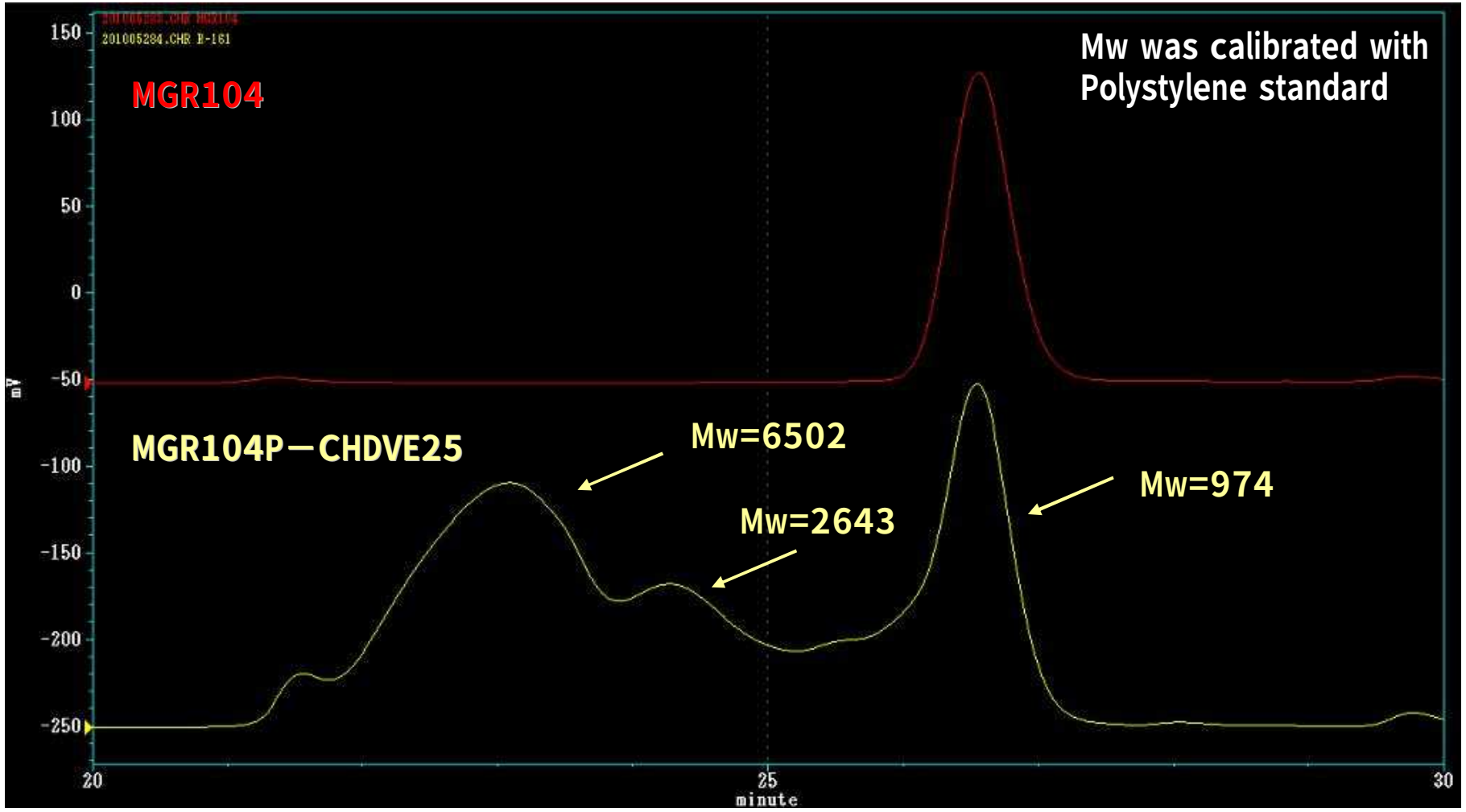


MGR104P－CHDVE25

- Amorphous
- High Etching Durability
  (Etching rate is same as PHS)
- High Glass Transition Temperature
- Good Solubility for Resist Solvents
- Good Solubility Rate for TMAH0.26N%aq.
  as a Positive-tone Resist Base.

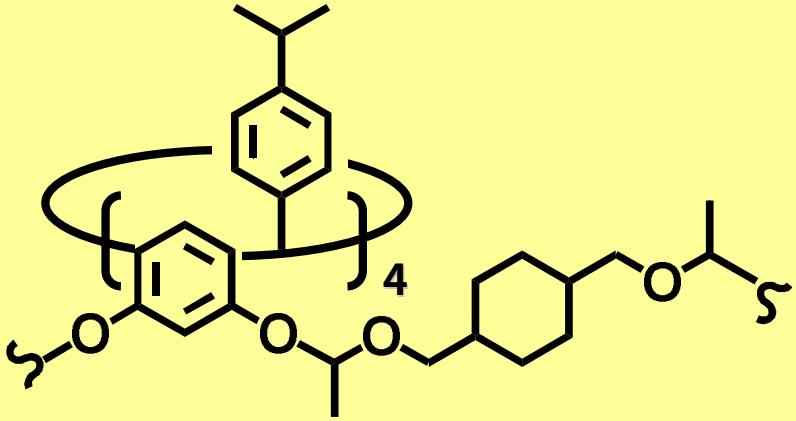
GPC Chromatogram of MGR104P-CHDVE25



The molecular weight of MGR104P-CHDVE25 is higher than that of MGR104.

Scheme of Possible Chain Scission Reaction

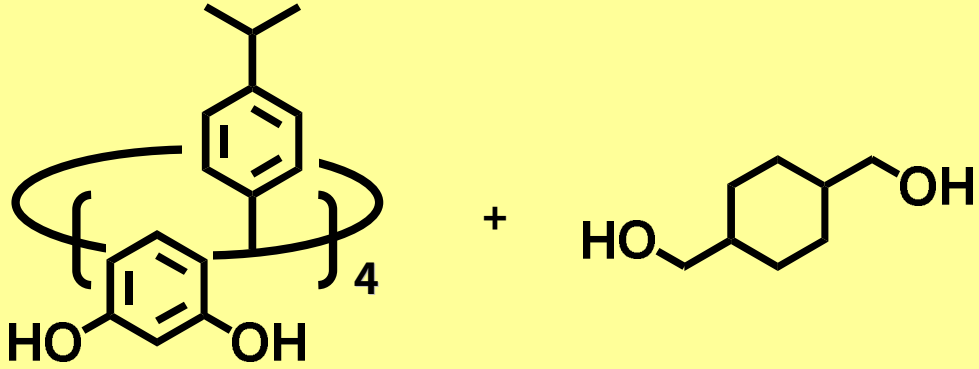
Insoluble for TMAH0.26N%aq.



MGR104P-CHDVE

H^+ / H_2O

Soluble for TMAH0.26N%aq.



MGR104 + + $H_2C=O$

EB Patterning Evaluations

Tool:

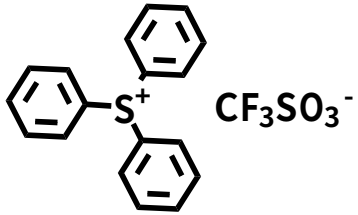
Ultra－High Precision EB Lithography System
(ELS－7500 ; Acceleration Voltage 50 keV)
at Mitsubishi Gas Chemical (MGC)

Process Conditions:

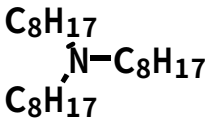
Substrate: Organic layer (UL)
Film Thickness: 40-60nm
PB&PEB: 70-110℃/90s
Dev.: TMAH 0.26N 60s

Resist Formulation

	Positive－tone Resist A
Resin	MGR104P－CHDVE25
PAG	TPS－PFMS
Quencher	TOA
Solvent	PGME



TPS－PFMS

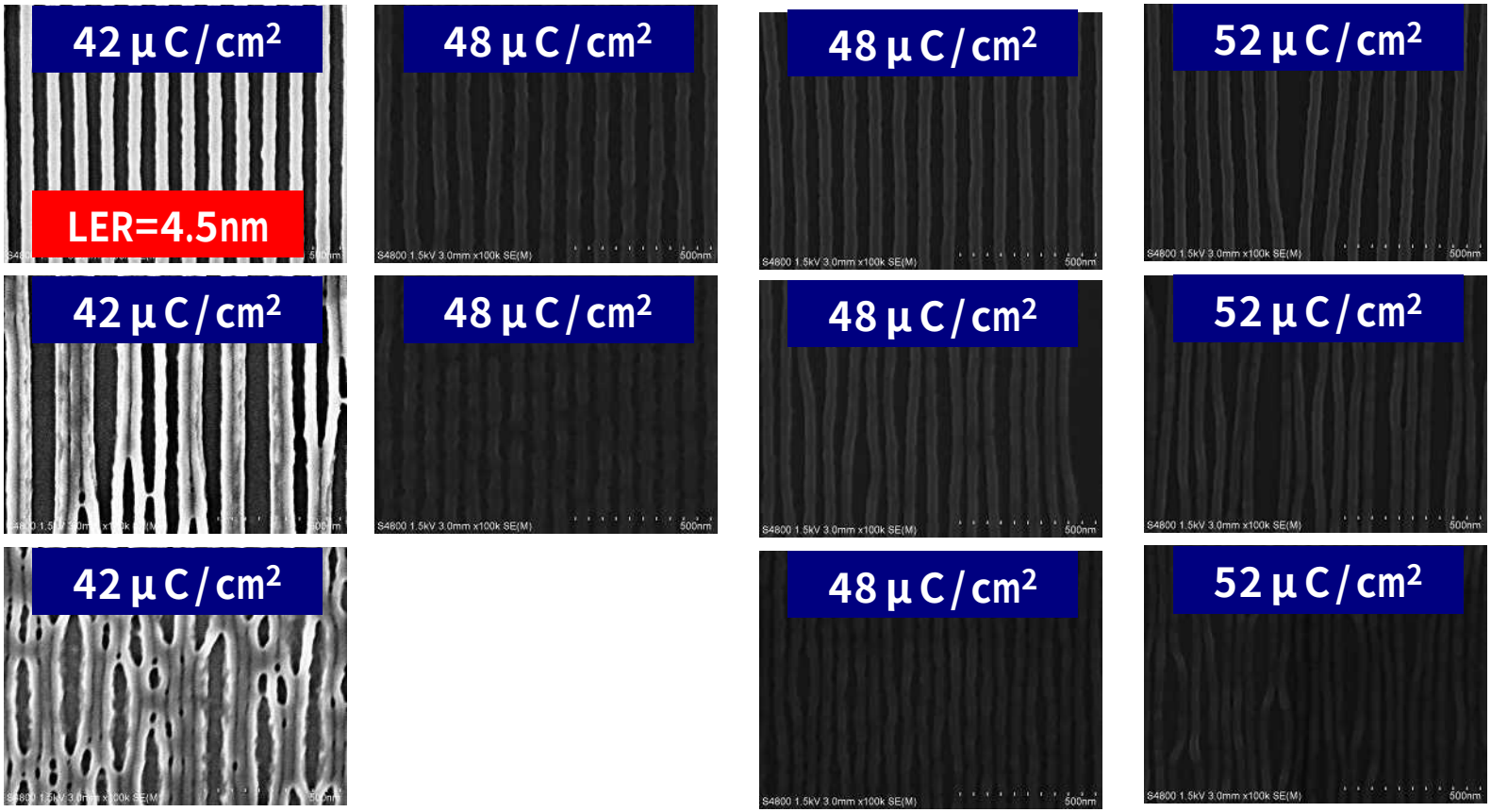


TOA

Resist formulation hasn't been optimized yet !!

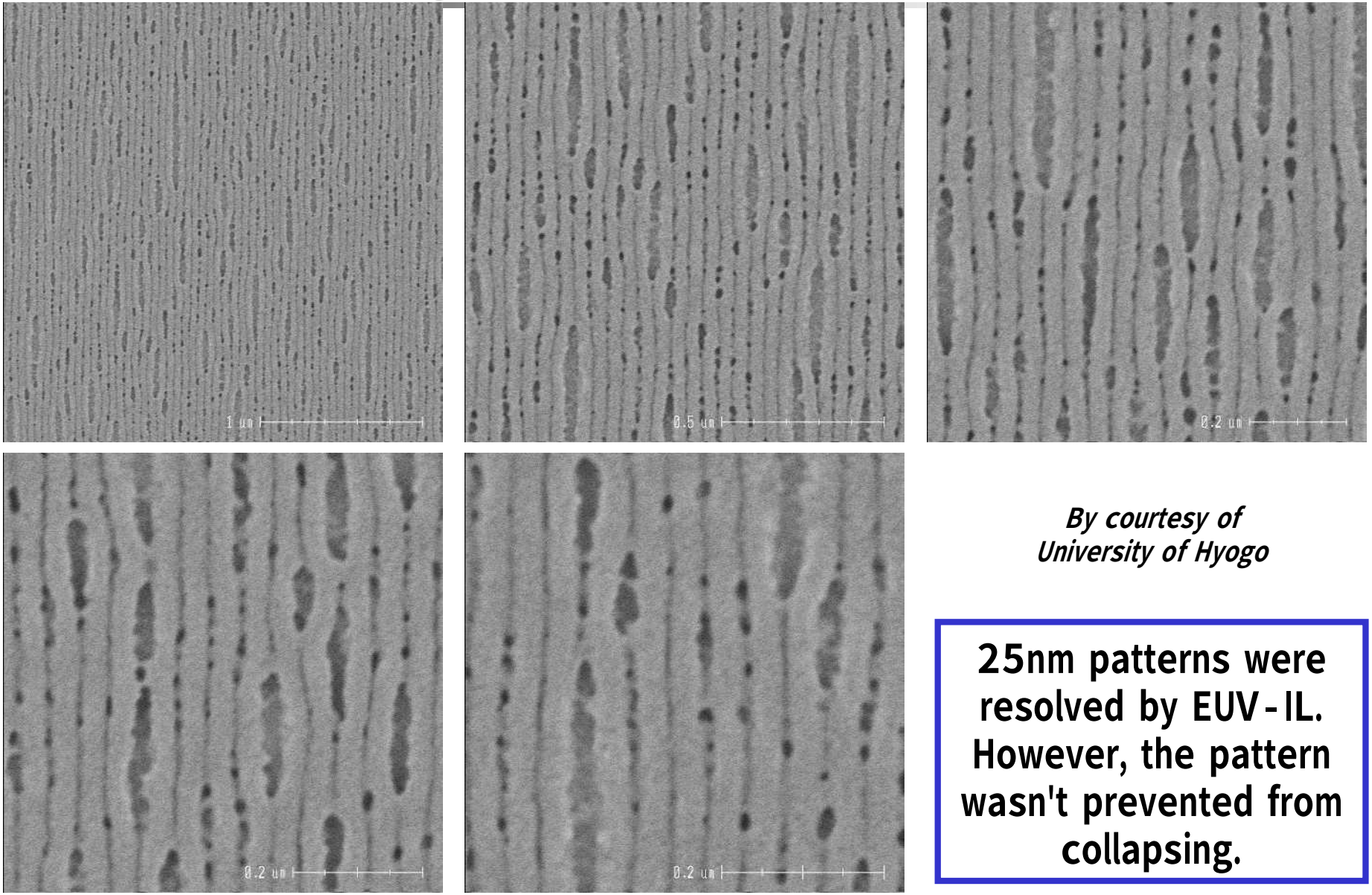
Patterning results of Resist A by EB

	60nmt,PEB110°C	40nmt,PEB110°C	40nmt,PEB90°C	40nmt,PEB70°C
50 nmLS	42 μC/cm² LER=4.5nm	48 μC/cm²	48 μC/cm²	52 μC/cm²
40 nmLS	42 μC/cm²	48 μC/cm²	48 μC/cm²	52 μC/cm²
30 nmLS	42 μC/cm²		48 μC/cm²	52 μC/cm²



Sub 30nm patterns were resolved by EB.
However, the pattern wasn't be prevented from collapsing.

Patterning results of Resist A by EUV-IL



By courtesy of
University of Hyogo

25nm patterns were resolved by EUV-IL. However, the pattern wasn't prevented from collapsing.

Summary

・We have developed new positive-tone molecular resist material cross-linked with protection group, MGR104P-CHDVE25. We investigated the application to positive-tone resist for EB and EUVL.

EBL: Resolution showed Hp 30 nm at an EB dose of 42 μC/cm^2.
EUVL: Resolution showed Hp 25 nm by EUV-IL.

・We confirmed the possibility of new positive-tone molecular resist material cross-linked with protection group for EB and EUVL.

Acknowledgement

・We would like to thank to Dr. T. Watanabe, Mr. Y. Fukushima and Dr. H. Kinoshita of University of Hyogo for useful discussions and for the evaluated by EUV-IL.